

Block Island and Coastal Virginia Offshore Wind Structural Monitoring Programs

BSEE Contract Nos. 140E0119C0003, 140E0122C0004

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Babak Moaveni, Aaron S. Bradshaw, Per Sparrevik

April 23, 2024



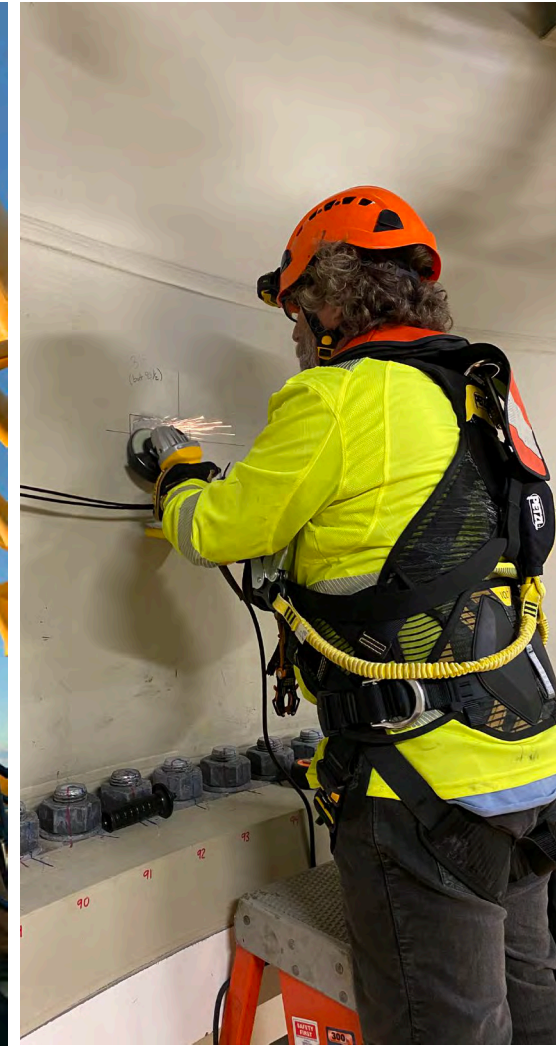
Outline

Acknowledgements

Research
Environment

Structural Health
Monitoring at BIWF
and CVOW

Conclusions



Acknowledgements

- James Strout, Katherine Quale, Henrik Meland, Stian Hovde (NGI)
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- Adam Cross, Frank Ackerman (Siemens Gamesa Renewable Energy)
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Optimal Sensor Placement for Physics-Based Digital Twins



Block Island



Wind Farm-Level Technology—2023

CVOW Instruments Installed—2022

BIWF Instruments Installed—2021

NOWRDC—2020

BISM-JP—2019

POWER-US—2018

BIWF Operational—2016



DOE Topic Area 1—2012

RI Ocean SAMP—2008

Levenmouth



Projects Leveraged by the Block Island Structural Monitoring Program

Innovate UK:
Offshore Renewable
Energy Catapult (OREC)

Transmission
Dynamics +
OREC

NOWRDC-OSP

Tufts
Lead
Desktop

CRMC + URI
Lead, Data
Collection

BSEE: Block Island
CRMC, URI, Tufts,
NGI, Ørsted, GE

UNR, NREL

Transmission Dynamics,
UNASYS, U. Strathclyde

BSEE + BOEM—CVOW
DOE—WFIP-3
NSF—PIRE (UK,DK,NO)
NOWRDC + Innovate UK
DENICAN Digitalization
OC-7
Developers
OEMs
Ocean Test Bed
Future of Digital Twins



Acknowledgements: Total Project Value

Grant	Total
BSEE Block Island Structural Monitoring-Joint Project	\$608,722
MassCEC Matching Funds	\$150,000
NOWRDC Optimal Sensor Placement	\$799,890
MassCEC Matching Funds	\$200,000
Innovate UK Matching Funds	\$777,072
Kingsbury Gift	\$650,000
CVOW Digital Twinning	\$750,000
NSF PIRE	\$1,498,144
NSF PIRE, MassCEC Adder	\$290,000
Total	\$5,723,828

Regulatory Environment Fostering Research and Collaboration

RHODE ISLAND COASTAL RESOURCES MANAGEMENT COUNCIL

BLOCK ISLAND WIND FARM STAFF STIPULATIONS

14. Research: (BIWF Assent only) Following notice, the wind turbine support structures shall be available for research projects approved by the Executive Director and which relate to the purposes of the OSAMP and that do not affect turbine operation, maintenance, emergency access or turbine warranties. Such availability shall be subject to participants agreeing to executing a release waiving all liability associated with such access and to any requirements of OSHA, ISPS, or other governmental agencies with jurisdiction and the wind turbine owner's site, insurance and HSE procedures and requirements and restrictions in place to protect persons and property.



Regulatory Environment Fostering Research and Collaboration

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF OCEAN ENERGY MANAGEMENT
Conditions of Research Activities Plan Revisions Approval
Lease Number OCS-A 0497
June 20, 2019

13. RESEARCH ACTIVITIES

13.1 The Lessee, by itself or through its designated operator, must conduct research activities, and/or make its facilities available to conduct research activities,

to the to the Lessor, its contractors, studies partners and, the National Renewable Energy Laboratory (NREL) in a manner consistent with the goals set forth in Appendices K (SCOUR AND SEABED MOBILITY STUDIES), U (DATA MEASUREMENT AND TESTING PLAN), and V (PRELIMINARY DISSEMINATION PLAN) dated February 2014. BOEM may from time to time request, and the Lessee or its designated operator must timely provide, updates on the status of such research activities.



Coastal Virginia
Offshore Wind – Pilot
(CVOW)

Structural Health Monitoring Projects

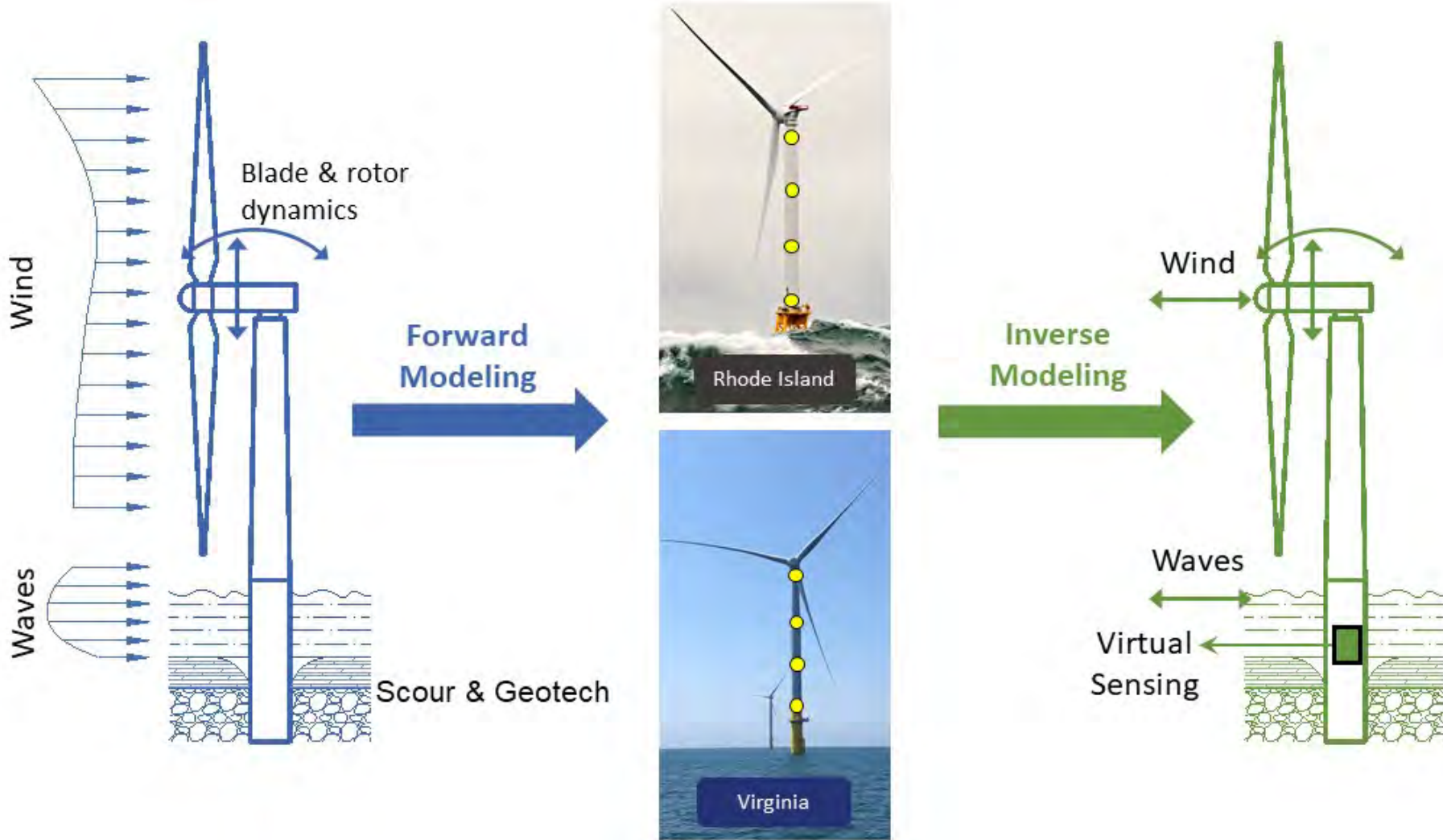
The objective of these studies are to design and install a continuous monitoring system to obtain a benchmark set of structural performance data that adequately represents the BIWF and the CVOW, including analyses of

- Modes of vibration
- Effects of soil stiffness and damping
- Assessment of fatigue



- Design Verification
- Predictive Maintenance
- Maximize Annual Energy Production (AEP)
- Service Life Extension

Physics-Based Digital Twins



Block Island Optimal Sensing

- 9-accelerometers + 8-strain gages + inclinometer
- Sampling frequency of 50 Hz
- Data is saved every 10 min

Open Access:

<https://www.sciencedirect.com/science/article/pii/S0960148122017670>



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Structural instrumentation and monitoring of the Block Island Offshore Wind Farm

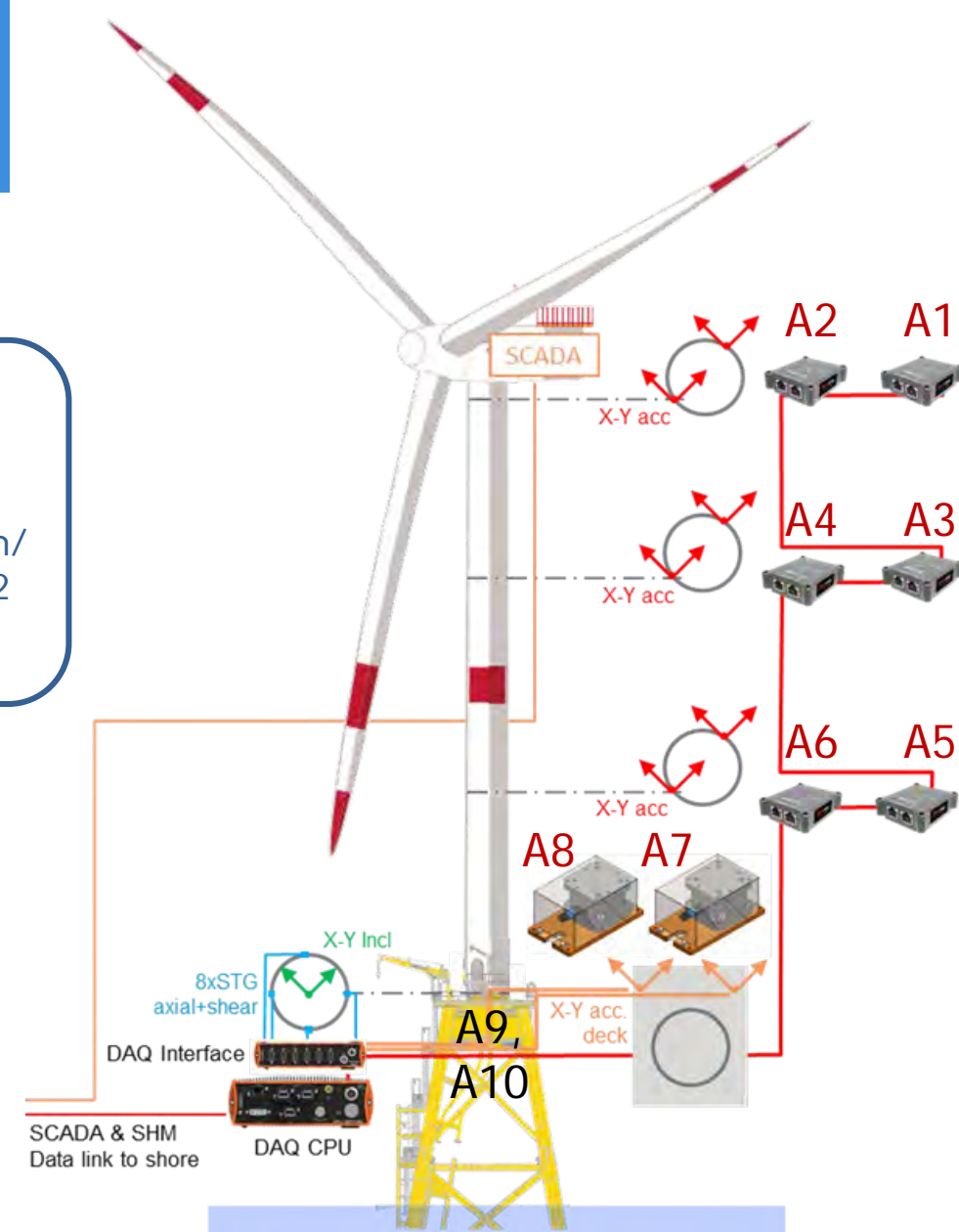
Eric M. Hines^a, Christopher D.P. Baxter^b, David Ciochetto^c, Mingming Song^{a,f}, Per Sparrevik^d, Henrik J. Meland^d, James M. Strout^d, Aaron Bradshaw^b, Sau-Lon Hu^b, Jorge R. Basurto^e, Babak Moaveni^a

Show more

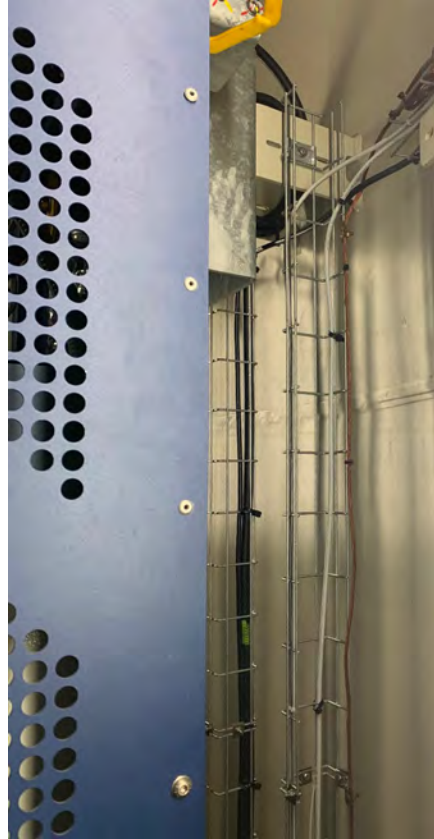
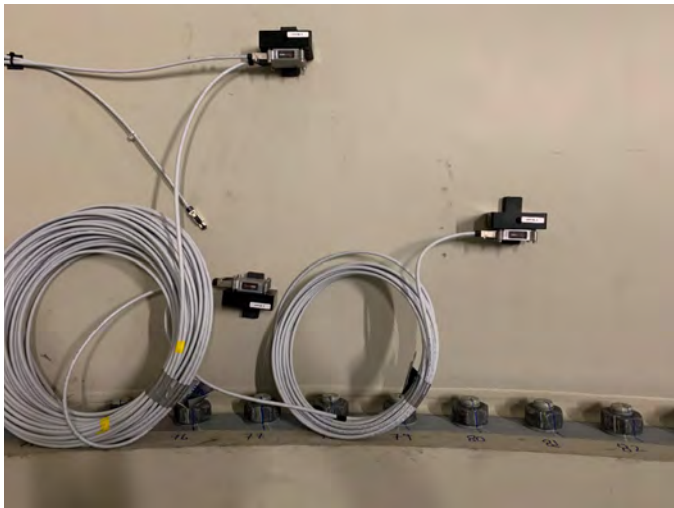
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<https://doi.org/10.1016/j.renene.2022.11.115> Get rights and content

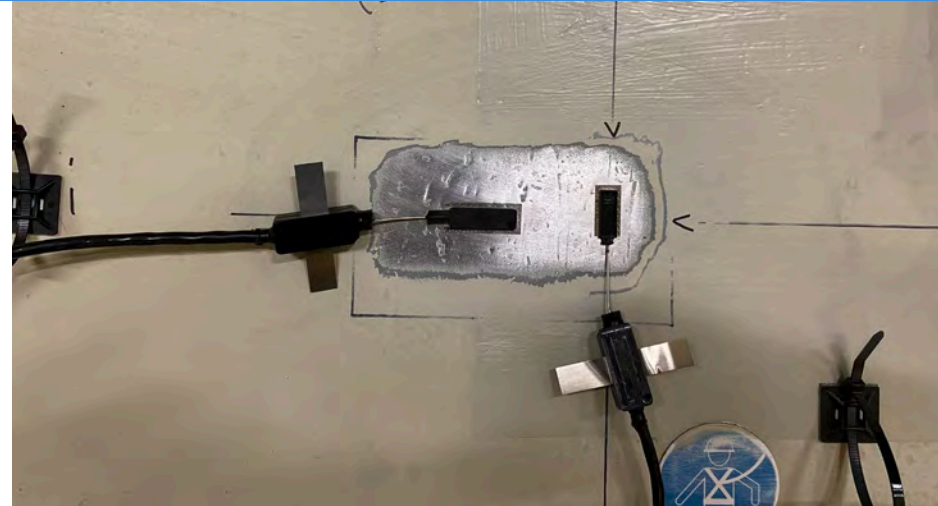
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Data collection started from April 18, 2021 (except strain)



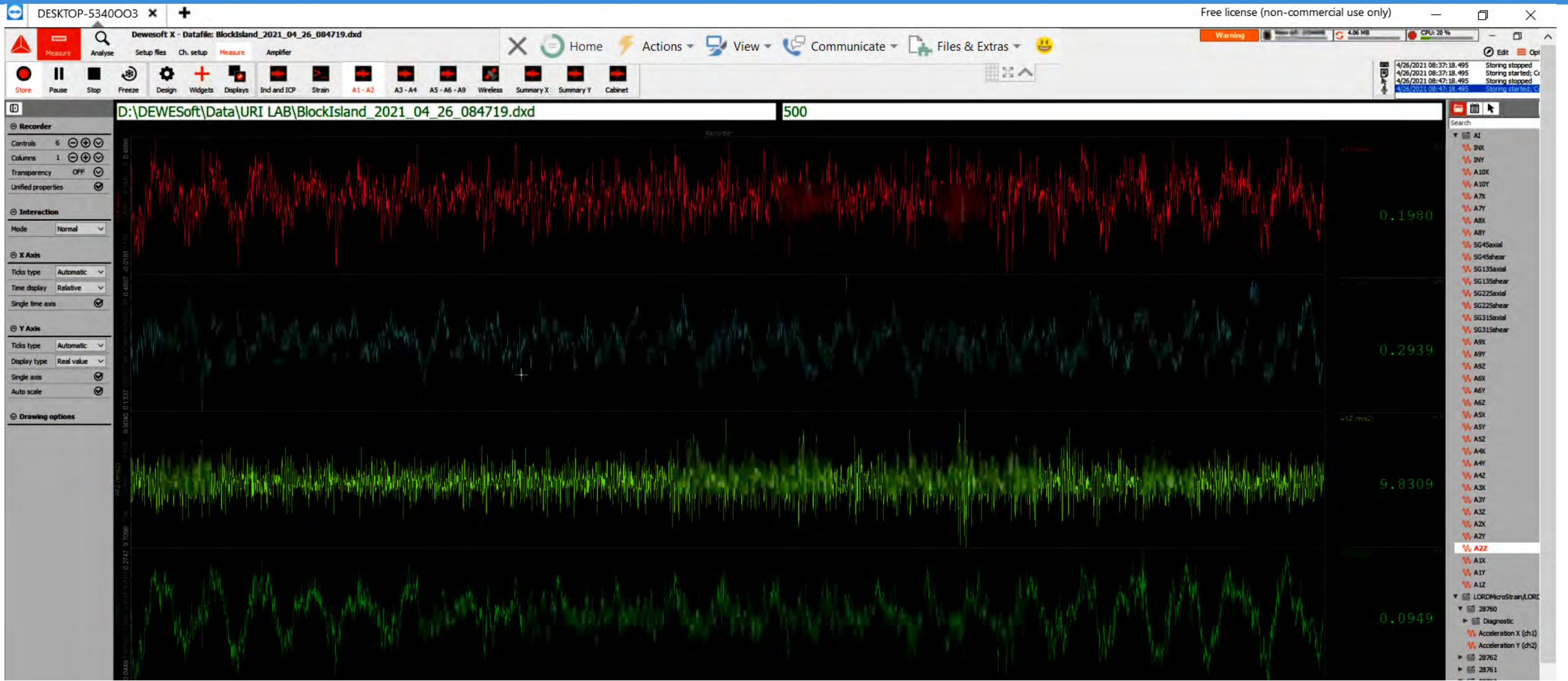
Strain gauges installed on October 24, 2021



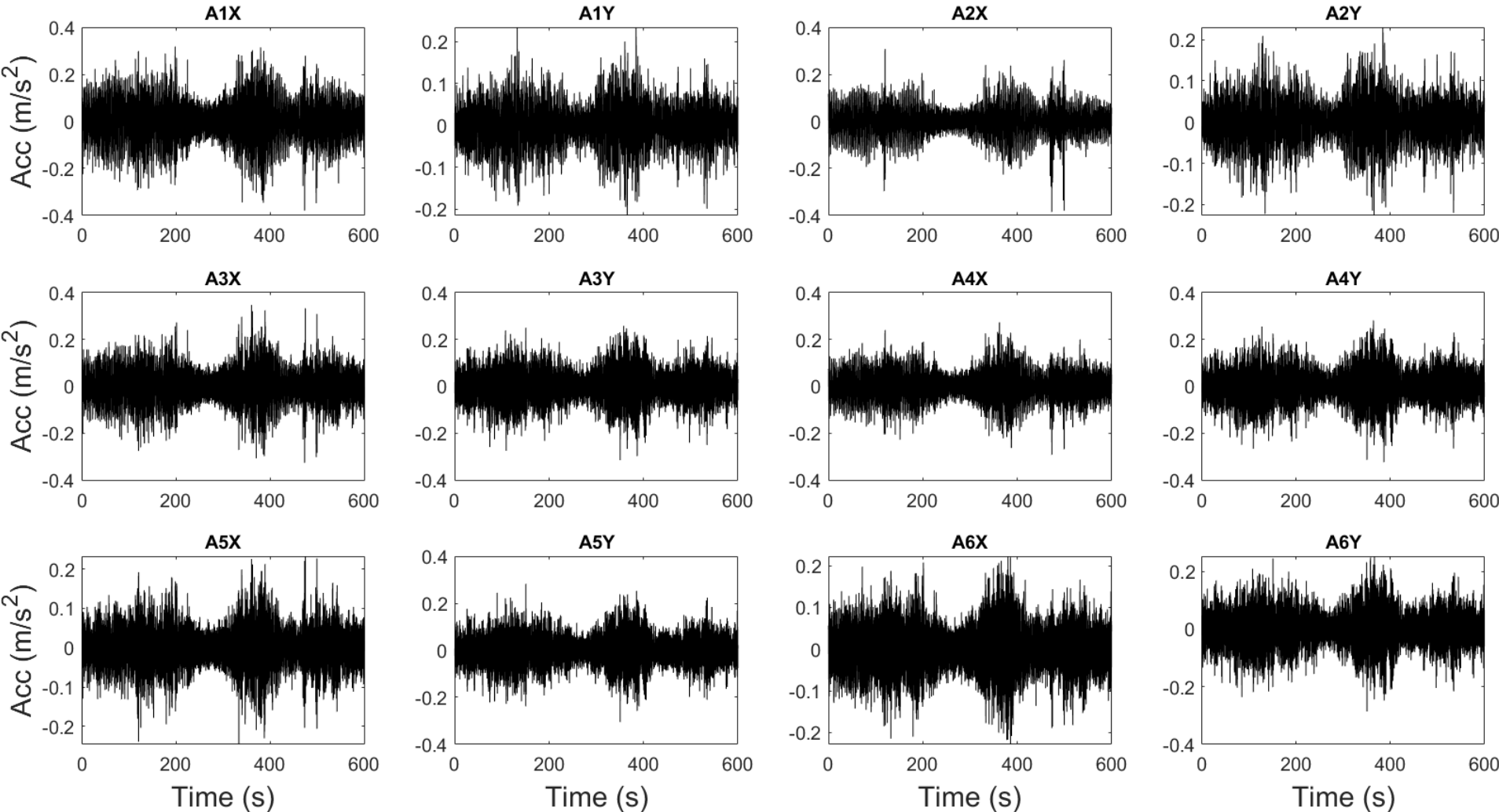
A couple of photos



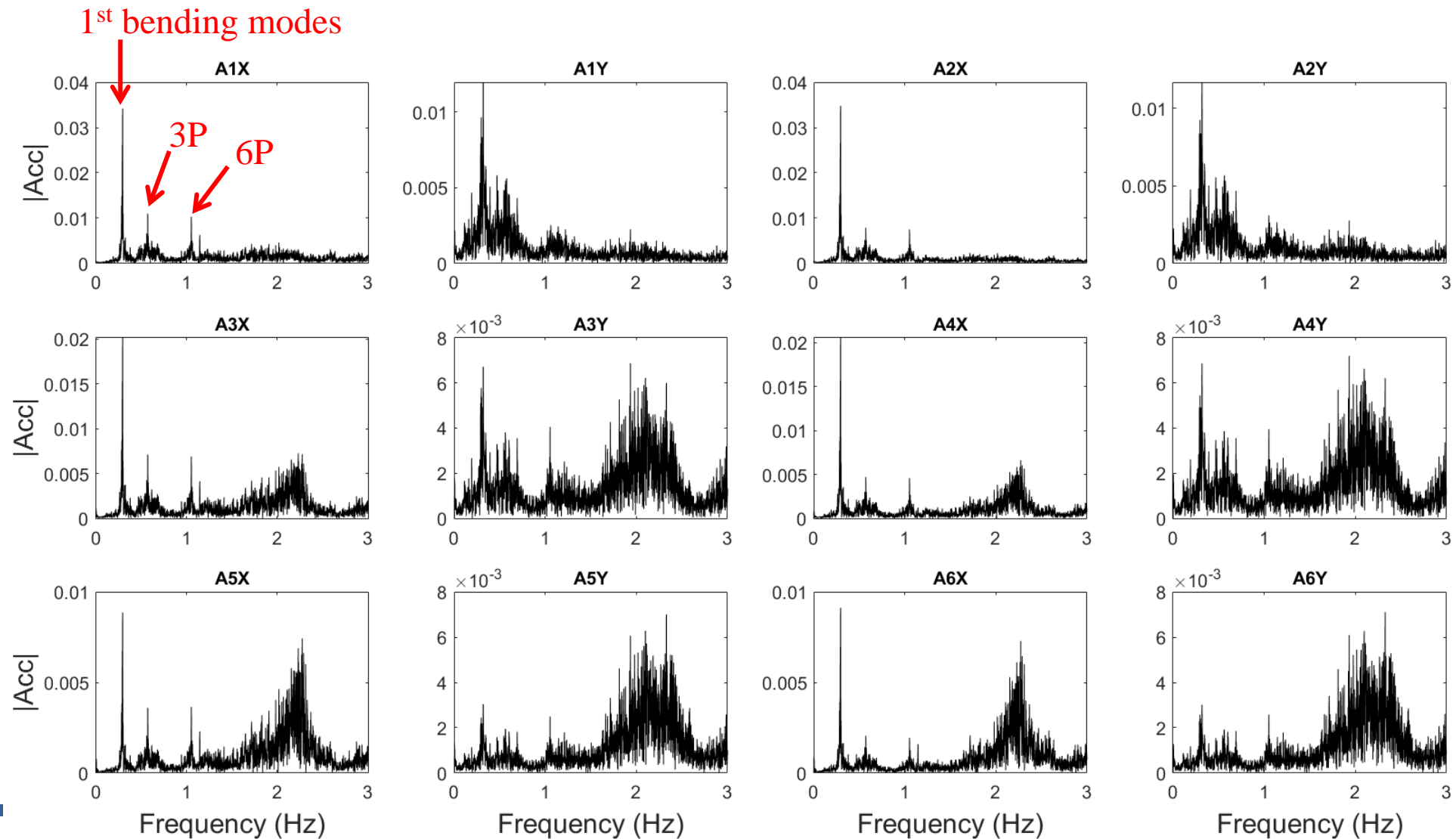
Live Data Stream



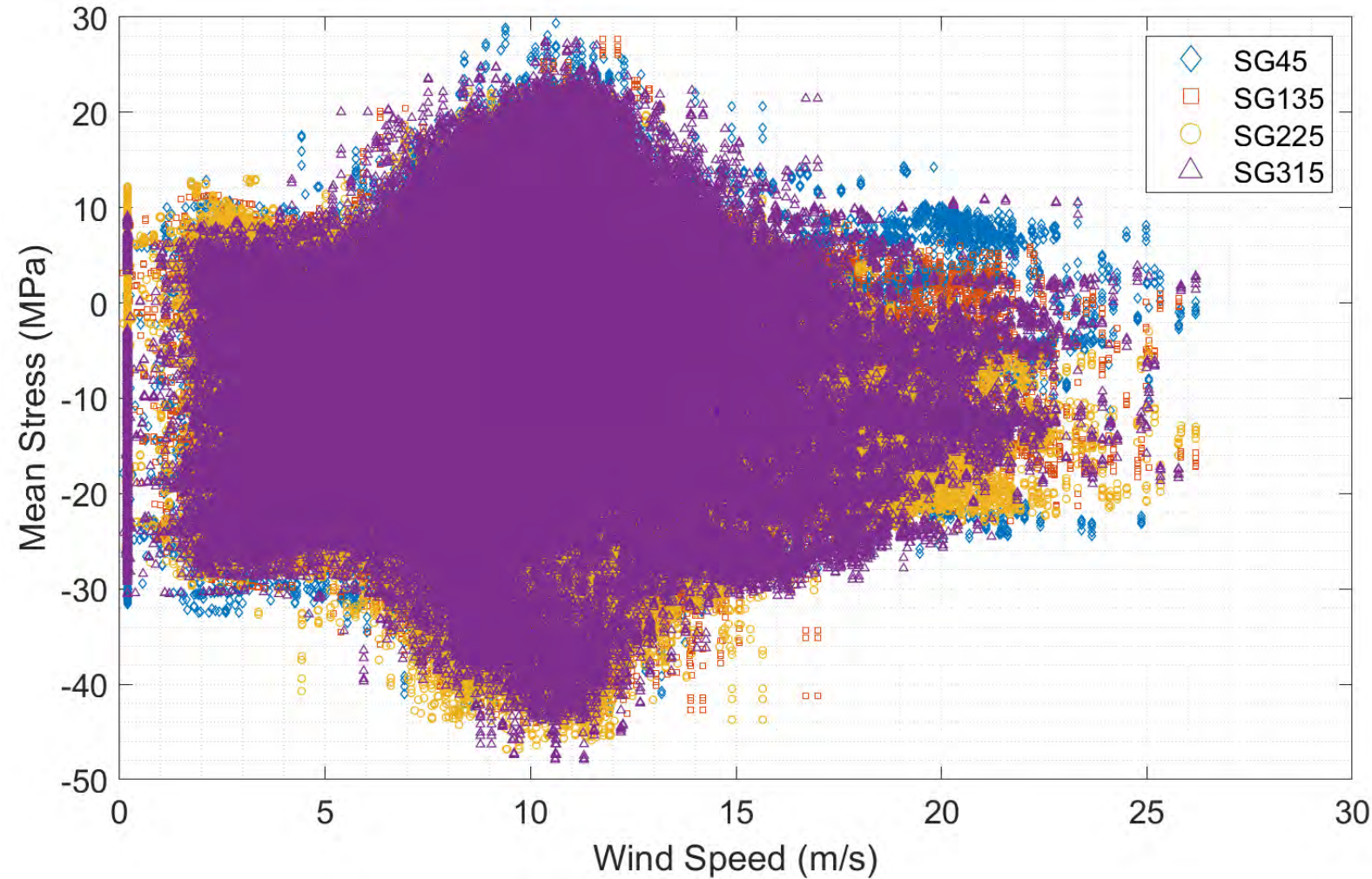
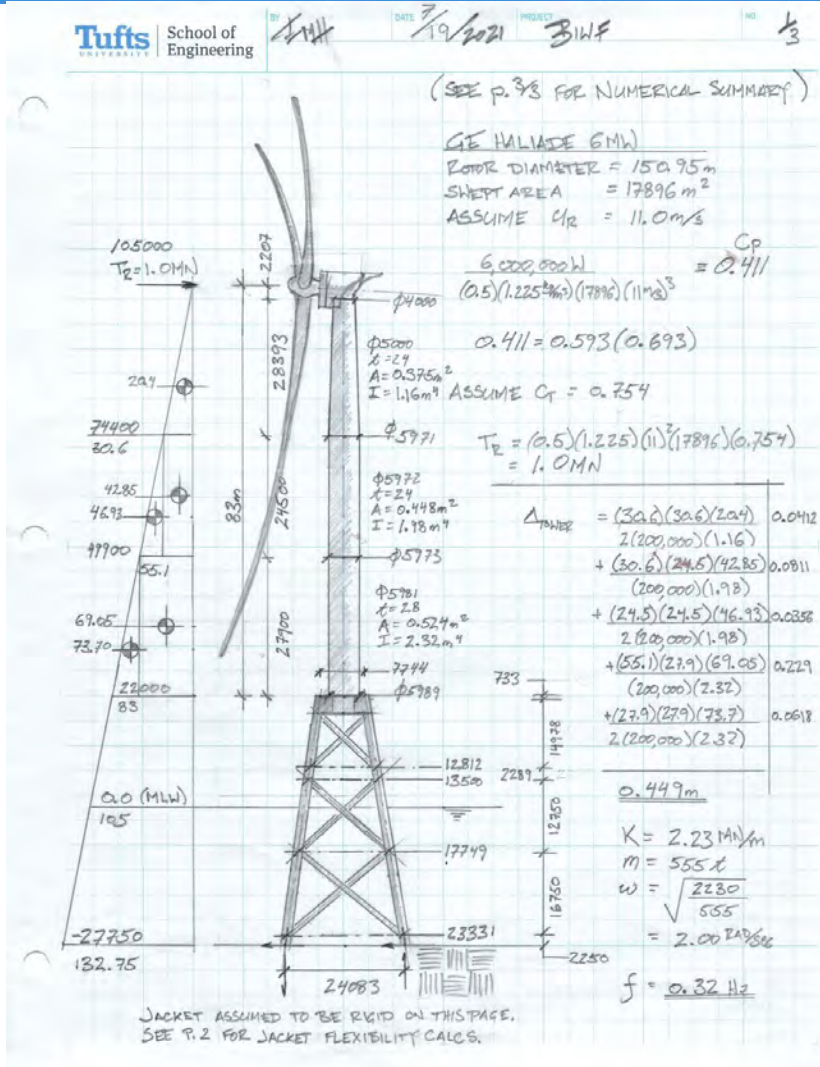
Acceleration Time History (April 22, 09:17)



Fourier Amplitude Spectrum (April 22, 09:17): in operation



Engineering understanding combined with cutting edge data



Conclusions

- The regulatory environment created by CRMC was essential in obtaining \$1.3 mil in research funding from BSEE
- Structural Health Monitoring continues at BIWF and CVOW
- Significant research continues at URI in SHM, noise monitoring, floating offshore wind, innovative foundations, and more...





Thank You!